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# Investigating undergraduate students' scientific understanding of laboratory safety

Romklao Artdej*

*Faculty of Education, Khon Kaen University, Khon Kaen 40002, Thailand*

**Abstract**

Laboratory instruction does not only provide students with practical experience but also identify hazard materials and laboratory safety. The purpose of this research study was to investigate Thai undergraduate students' scientific understanding of safety signs. The survey questionnaire was administered to fourth-year undergraduate students at the Faculty of Education who enrolled chemistry laboratory instruction course. The findings indicated that a majority of the students misunderstood the definition of chemical hazards. In addition, they experienced confusion in matching chemicals commonly found in school science laboratory (i.e., sodium hydroxide) and the meaning of chemical safety sign. The interview revealed that they did not pay attention to safety signs labeled on containers during conducting experiments. The findings from this study provide basic information for teaching and learning in the course to promote students' awareness of the proper handling, storage and disposal of hazardous materials.



*Keywords:* Safety signs, laboratory safety, undergraduate students;

## 1. Introduction

Laboratory or practical work is considered a crucial component for students in science learning (Dechsri, Jones, & Heikkinen, 1997; Gee & Clackson, 1992; Högström, Ottander, & Benckert, 2010; Nakhleh, Polles, & Malina, 2002). It is a process that students learn parallel to science content to help them develop abilities necessary to do scientific inquiry and gain understanding about scientific inquiry (National Research Council, 1996). However, providing opportunities for students in conducting experiment should be accompanied by the rise of concern for chemicals or other hazardous substances and laboratory safety (Alaimo, Langenhan, Tanner, & Ferrenberg, 2010).

Chemicals provide many advantages for enhancing quality of life but they endanger for the environment whenever students used them without carefulness (Office of Research and Development, 2011). Paying attention to potential hazards in chemicals in the science laboratory is necessary for teachers (Moore, 2001). Teachers play an important role to encourage students to concern hazardous chemicals and to support safe habits in the laboratory session continually, for example the proper handling, storage and disposal of chemicals (Alaimo, et al., 2010). Students should follow all these suggestions given by teachers. In other word, safety in the science laboratory should be primary concern to both teachers and students.

* Romklao Artdej. Tel.: +6-681-835-1865
*E-mail address*: romklao@kku.ac.th

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Previous research studies in science education demonstrated that teachers attempted to help students concern hazardous chemicals through learning activities, for example games (Gublo, 2003), comic book labs (Raddo, 2006), videos (Matson, Fitzgerald, & Lin, 2007), and computer simulations (Bell & Fogler, 1999). However, some studies reported that students were not aware and misunderstood about the use of hazardous chemicals (Alaimo, et al., 2010; Karapantsios, Boutskou, Touliopoulou, & Mavros, 2008). According to Wiediger and Hutchinson (2002), the risk of an accident would be occurred in the laboratory if students hold misconception to interpret labels appeared on chemical containers. As a result, many science educators had paid attention to explore student misconceptions in order to help them reconstruct their scientific conception (Mulford & Robinson, 2002).

This study highlighted the understanding of safety signs that students have seen or experienced prior to entering the laboratory because safety signs help to reinforce students safe handling of chemicals. Specifically, this research sought to answer the following research question: What are Thai undergraduate students' understandings of safety signs?

## 2. Research objective

The purpose of this study was to investigate Thai undergraduate students' understanding of safety signs.

## 3. Method

### *3.1. Research design*

This study was conducted to investigate Thai undergraduate students' understanding of safety signs by using survey research.

### *3.2. Participants*

The participants in this study were 27 fourth-year undergraduate students at the Faculty of Education who enrolled chemistry laboratory instruction course. Thirteen students were in chemistry major and 14 students were in general science major. Major course (e.g., fundamental chemistry, organic chemistry) that students needed to study at the Faculty of Science were mainly required in the first two years of program. Teaching courses (e.g., chemistry laboratory instruction course, science learning organization for basic education) that students needed to study at the Faculty of Education were mainly required in the three remaining years of program.

### *3.3. Instruments*

A questionnaire used in this study was adapted by Karapantsios, Boutskou, Touliopoulou, and Mavros (2008). An example of this questionnaire was shown in Table 1. In this investigation, it was translated from an original English version into Thai version. The questions in this questionnaire required the students to match a list of 20 chemicals in column A and of nine safety signs accompanied with a short description in column B. This aimed to reduce the wrong response because the students incorrectly considered only the symbol.

A semi-structured interview was also used to elicit students' understanding of safety signs. Interview questions covered all safety signs which appeared in the questionnaire.

### *3.4. Data collection*

The survey questionnaire was administered in the initial schedule of chemistry laboratory instruction course prior to getting started teaching and learning activities. Students took approximately 30-40 minutes to complete the questionnaire. Three students from all participants were randomly selected to individually interview. Each interviewee was asked the same questions regarding the meaning of safety signs and was interviewed for approximately 10 minutes.

Table 1. The questionnaire used in this study

| Column A | | Answer | Column B | |
|---|---|---|---|---|
| A | Turpentine | ………….. | 1 | T  Toxic |
| B | Hydrochloric acid | ………….. | | |
| C | Chlorine (Javel water) | ………….. | 2 | Xn  Harmful |
| D | Colloid suspension of polychloroprene | ………….. | | |
| E | Styrene | ………….. | 3 | c  Corrosive |
| F | Oils and greases | ………….. | | |
| G | Ammonium hydroxide 20% | ………….. | 4 | Xi  Irritating |
| H | Methyl ethyl ketone | ………….. | | |
| J | Toluene | ………….. | 5 | E  Explosive |
| K | Sodium hydroxide | ………….. | | |
| L | Epoxy resin | ………….. | 6 | O  Oxidative |
| M | Trichloroethylene | ………….. | | |
| N | Hydrogen peroxide | ………….. | 7 | F  Flammable |
| O | Dichlorodifluoromethane | ………….. | | |
| P | Phenol | ………….. | 8 | No sign |
| Q | Lead oxide | ………….. | | |
| R | Sodium cyanide | ………….. | 9 | N  Dangerous to the environment |
| S | Petrol | ………….. | | |
| T | Sodium chloride | ………….. | | |
| U | Mercury (II) fulminate | ………….. | | |

## 3.5. Data analysis

Students' responses from the questionnaire were analyzed by the researcher. A correct answer which indicated students could match a chemical name with its safety sign were coded one and an incorrect answer which indicated students could not match a chemical name with its safety sign were coded zero. The frequency, percentage, and mean score of students' responses were calculated. Interview data were analyzed in order to obtain more information about students' understanding of safety signs.

## 4. Results and discussion

Data from the administration of the questionnaire showed that most students had low scores with a mean score of 5.0. The frequency and percentage of students' responses (e.g., correct, incorrect, and no answers) to 20 questions of the questionnaire were presented in Table 2. Figure in bold indicated the majority of students' responses.

Table 2. Frequency and percentage of students' responses (N=27)

| List of chemical names | Correct answers | | Incorrect answers | | No answers | |
|---|---|---|---|---|---|---|
| | f | (%) | f | (%) | f | (%) |
| Turpentine | 2 | 7.4 | **25** | **92.6** | 0 | 0.0 |
| Hydrochloric acid | **27** | **100.0** | 0 | 0.0 | 0 | 0.0 |
| Chlorine (Javel water) | 3 | 11.1 | **24** | **88.9** | 0 | 0.0 |
| Colloid suspension of polychloroprene | 2 | 7.4 | **23** | **85.2** | 2 | 7.4 |
| Styrene | 9 | 33.3 | **17** | **63.0** | 1 | 3.7 |
| Oils and greases | 8 | 29.6 | 19 | **70.4** | 0 | 0.0 |
| Ammonium hydroxide 20% | 10 | 37.0 | 17 | **63.0** | 0 | 0.0 |
| Methyl ethyl ketone | 3 | 11.1 | 24 | **88.9** | 0 | 0.0 |
| Toluene | 6 | 22.2 | 21 | **77.8** | 0 | 0.0 |
| Sodium hydroxide | 8 | 29.6 | **19** | **70.4** | 0 | 0.0 |
| Epoxy resin | 2 | 7.4 | **24** | **88.9** | 1 | 3.7 |
| Trichloroethylene | 7 | 25.9 | **20** | **74.1** | 0 | 0.0 |
| Hydrogen peroxide | 5 | 18.5 | **22** | **81.5** | 0 | 0.0 |
| Dichlorodifluoromethane | 0 | 0.0 | **26** | **96.3** | 1 | 3.7 |
| Phenol | 0 | 0.0 | **27** | **100.0** | 0 | 0.0 |
| Lead oxide | 8 | 29.6 | 19 | **70.4** | 0 | 0.0 |
| Sodium cyanide | 15 | **55.6** | 12 | 44.4 | 0 | 0.0 |
| Petrol | 18 | **66.7** | 9 | 33.3 | 0 | 0.0 |
| Sodium chloride | 0 | 0.0 | **27** | **100.0** | 0 | 0.0 |
| Mercury (II) fulminate | 9 | 33.3 | **18** | **66.7** | 0 | 0.0 |

The findings indicated that most students were unable to match 17 chemicals (e.g., ammonium hydroxide 20%, sodium hydroxide, and sodium chloride) with their safety sign correctly. There were only three chemicals (i.e., hydrochloric acid, sodium cyanide, and petrol) that most students were able to match with their safety sign correctly. The interview showed that three of these chemical were commonly found in laboratory school science. Surprisingly, sodium hydroxide and sodium chloride were also available in laboratory but the students misunderstood their meaning of safety sign. Most students incorrectly considered that sodium hydroxide was not corrosive. In fact, solid or solution of sodium hydroxide can cause severe burns if students contact without safety equipments such as goggles and gloves. Therefore, it should be labeled as corrosive. Most students also incorrectly thought that sodium chloride was not danger for health. It was possible that the students could use it in their daily life, so they did not aware general hazard information. Actually, sodium chloride is slightly hazardous in case of skin and eye contact (irritant).

Additionally, the interview data demonstrated that some students understood the meaning of all safety signs but they had no ideas what chemicals appropriately match to their safety signs. Moreover, they did not pay attention to safety signs labeled on containers during conducting experiments. Concerning the use of chemicals occurred when the laboratory direction was clearly explained. For these reasons mentioned above, students' scientific understandings were slightly found in this study.

## 5. Conclusion and implications

The findings from this study showed that a great majority of students misunderstood the meaning of safety signs. This study provides information for further research to find out teaching strategies to improve students' understanding of safety signs. Also, this study raises a question about adjusting teaching and learning in a chemistry instruction course to promote students' awareness of safety signs. It is an important thing for teachers to do all the time in the science laboratory and should be encouraged together with enhancing scientific understanding.

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